

## Report on CGMS-50 (2022)

**Co-Chairs:** Ulrich Foelsche (University of Graz),  
Sean Healy (ECMWF) → Hui Shao (NOAA/UCAR)  
**Rapporteur:** Tony Mannucci (NASA/JPL)

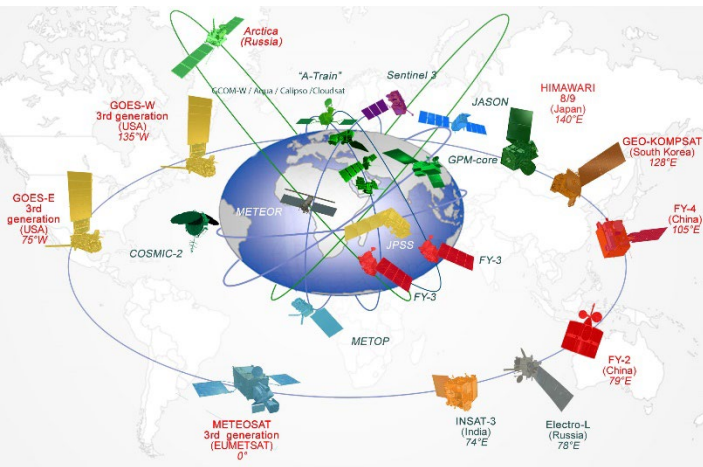
# IROWG will report to CGMS 51 WG II: April 2023, Plenary: June 2023

Remember: there is only a very **short window of attention**, which needs to be **exploited**.



# Lessons learned

- IROWG main recommendations need to be **short** and **concise**.
- They need to be formulated in a way, that they can result in CGMS **recommendations** or **actions**.



# Update From the International Radio Occultation Working Group

Presented to CGMS-50, WG II, agenda item 3

**Co-Chairs:** Ulrich Foelsche (University of Graz),  
Sean Healy (ECMWF)

**Co-Chair elect:** Hui Shao (JCSDA)

**Rapporteur:** Tony Mannucci (NASA/JPL)

# Overview

- IROWG co-chair election
- Impact of RO data in NWP
- Future status of RO and impending gaps
- IROWG-8 main recommendations
- Action item review
- IROWG-9

# IROWG Status

- The IROWG community has not met since IROWG-8 in April 2021. The main recommendations from IROWG-8 are still valid.
- Dr. **Sean Healy** is stepping back as IROWG co-chair. His dedication and his support over many years is much appreciated by the IROWG community!
- Dr. **Hui Shao** (Joint Center for Satellite Data Assimilation) was elected by the IROWG community. The formal handover will happen at the upcoming IROWG meeting in September 2022.



# IROWG-8 Science Highlights (1)

- The “GPS” RO Technique is now a true “GNSS” RO Technique, where **signals from all GNSS constellations** are being exploited.
- A **better penetration into the lowest kilometers** allows for studying the **planetary boundary layer** – including tropospheric **water vapor**.
- GNSS-RO data with **high spatial and temporal resolution** allow for unprecedented studies of **atmospheric** and **ionospheric** phenomena.



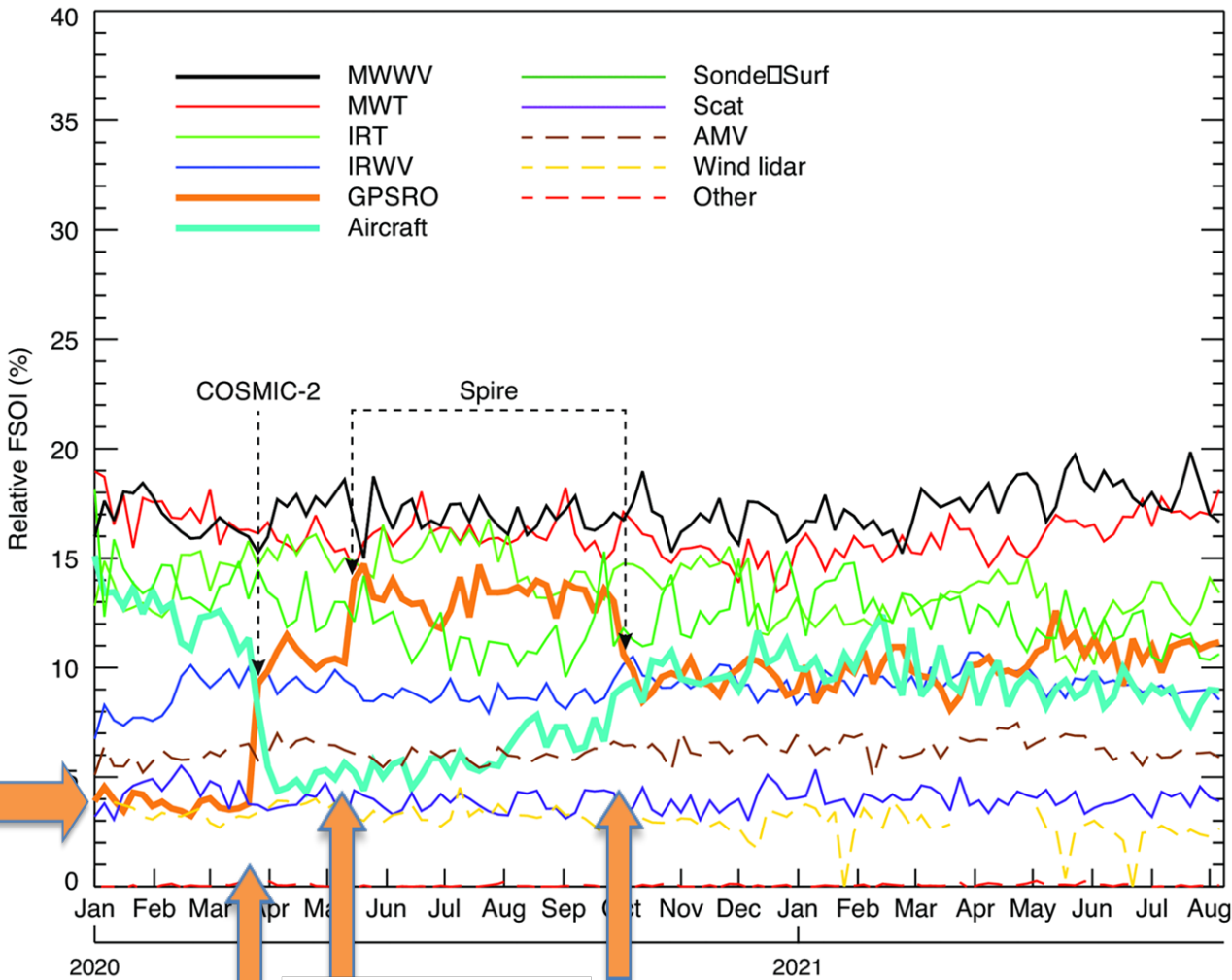
# IROWG-8 Science Highlights (2)

- GNSS-RO data demonstrate a **high impact in NWP** – not only in the UTLS, but **also in the lower troposphere** (water vapor). This impact clearly increases with the number of high-quality profiles – without any sign of “saturation”.
- **Commercial GNSS-RO missions** have reached **operational quality** (at least in the **UTLS**), and could **help to close the identified gaps in geographic and local-time coverage** – provided that they are **made available for the scientific and NWP communities**.
- GNSS-RO climate data advance **climate change monitoring** and contributed to the **latest IPCC assessment report**.

UTLS: upper troposphere, lower stratosphere



Bin size 5 days



Spire May 13

End of Spire data provision, Sep 30, 2020

COSMIC-2 March 25, 2020

Coordination Group for Meteorological Satellites

Operational Forecast Sensitivity to Observation Impact (FSOI) timeseries

## Impact of RO data in NWP

Integrated measure of 24-hour forecast impact at ECMWF

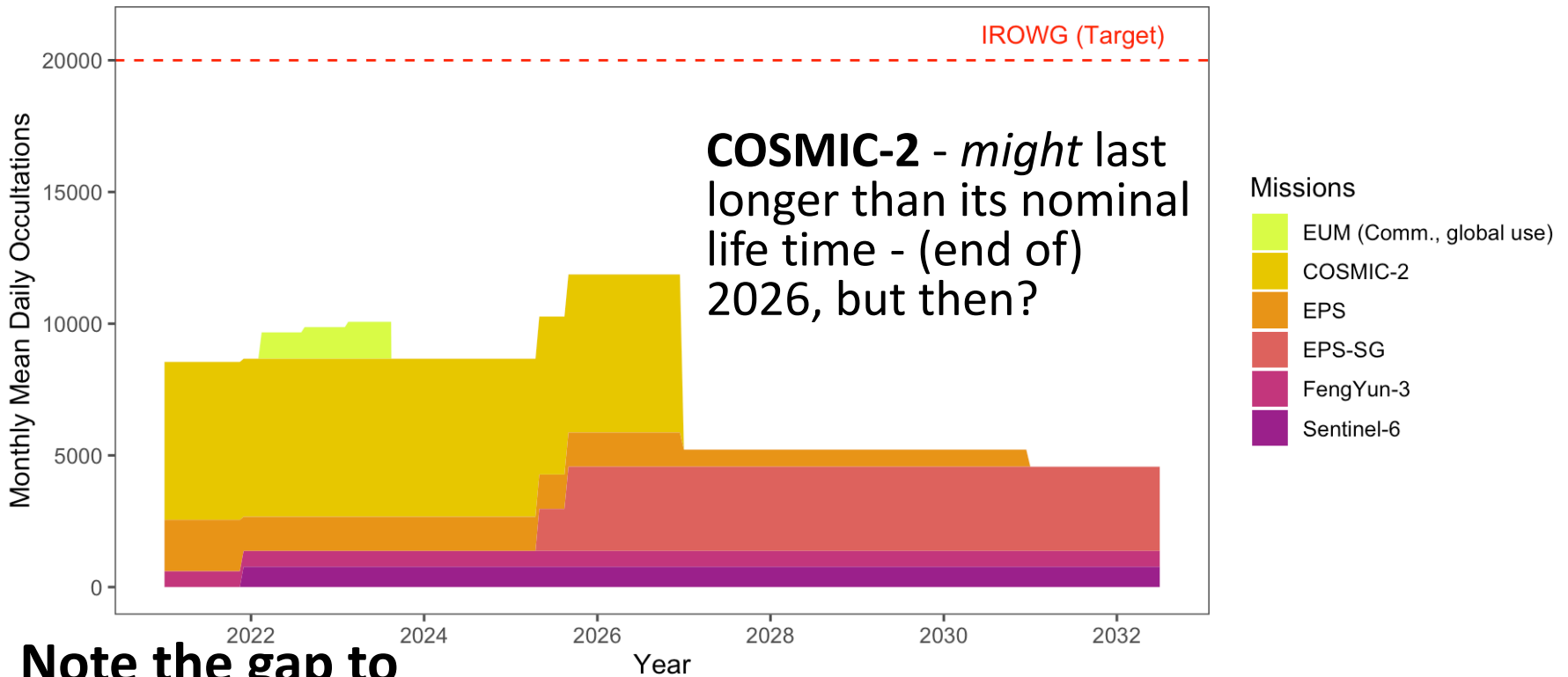


Impact increases clearly with # of RO profiles, no saturation



# Future Status of RO

Monthly Mean Daily RO Numbers (NRT)  
(as available today or from mission requirements)



EUMETSAT (May 2022)

**Note the gap to the target of 20000 profiles per day.**

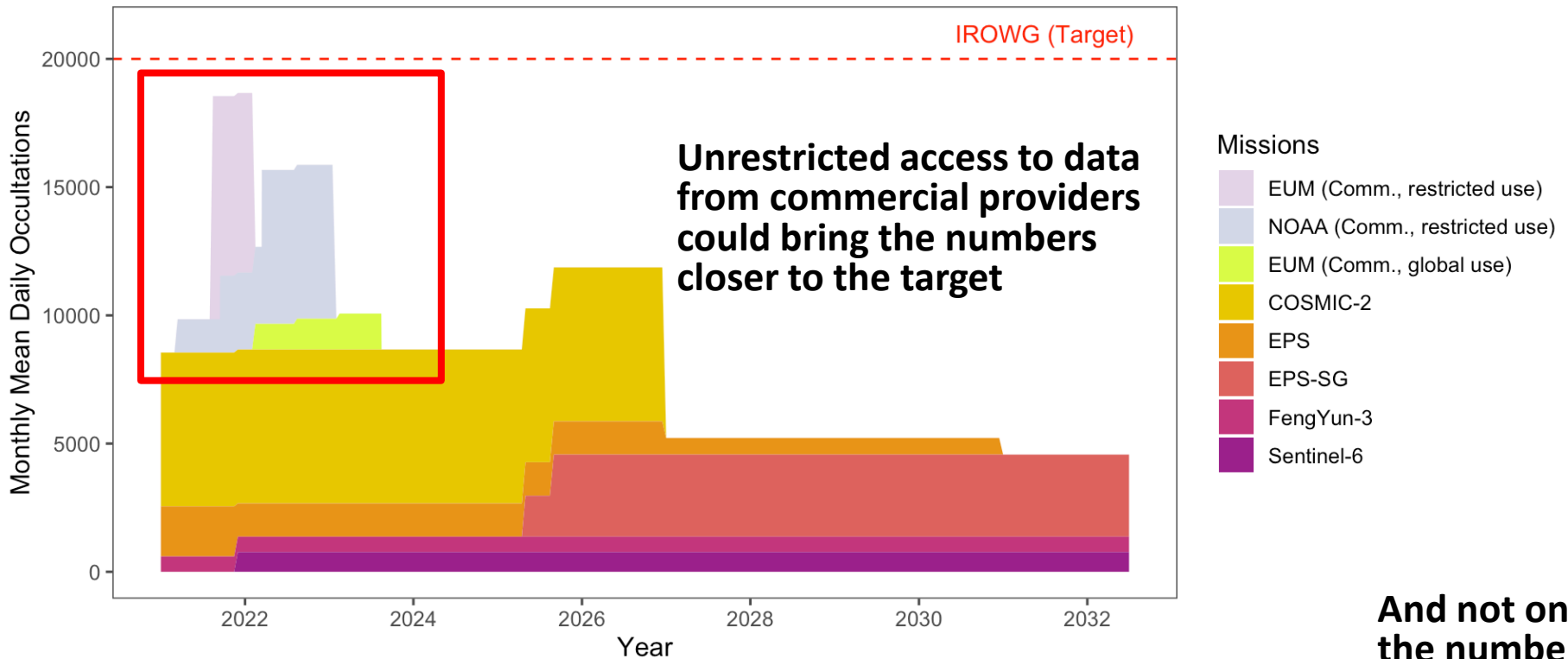
- Predicted numbers based on WMO/OSCAR
- Only operational missions with secured funding
- Nominal (baseline) mission performance
- GNSS constellations nominal

**Coordination Group for Meteorological Satellites**



# Future Status of RO

Monthly Mean Daily RO Numbers (NRT)  
(as available today or from mission requirements)

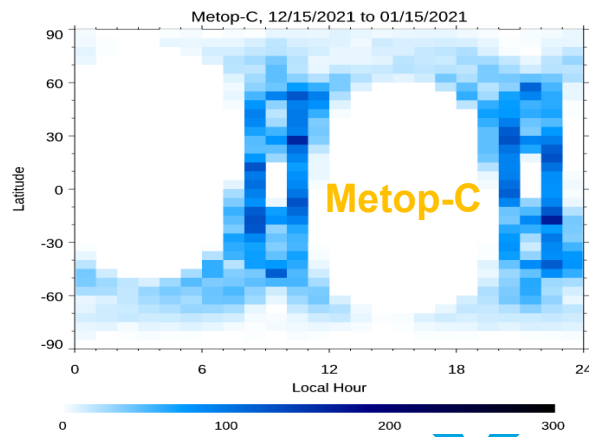
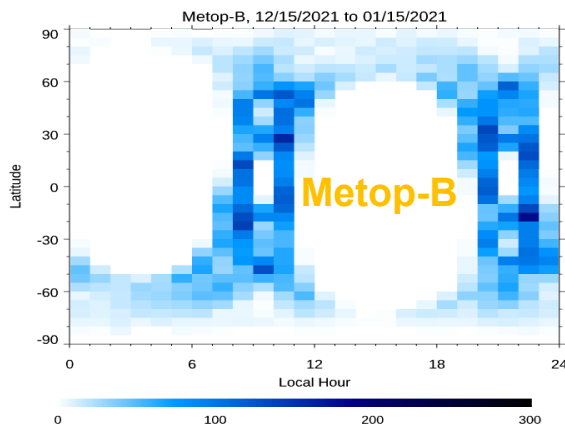
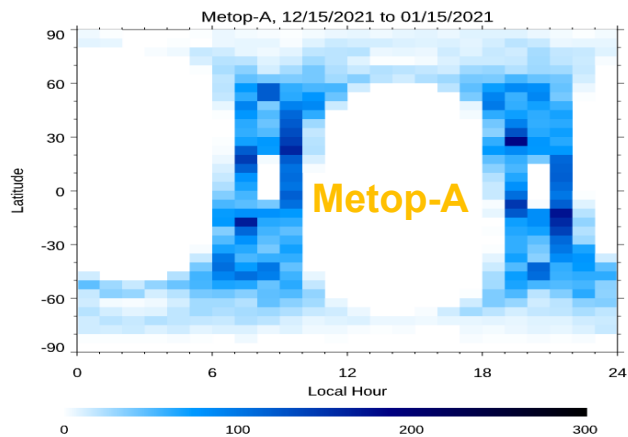
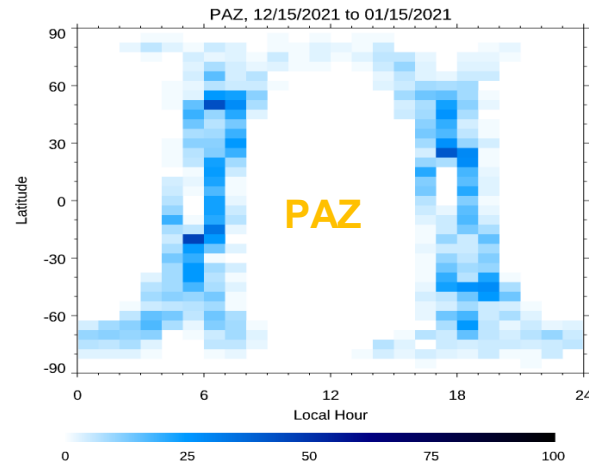
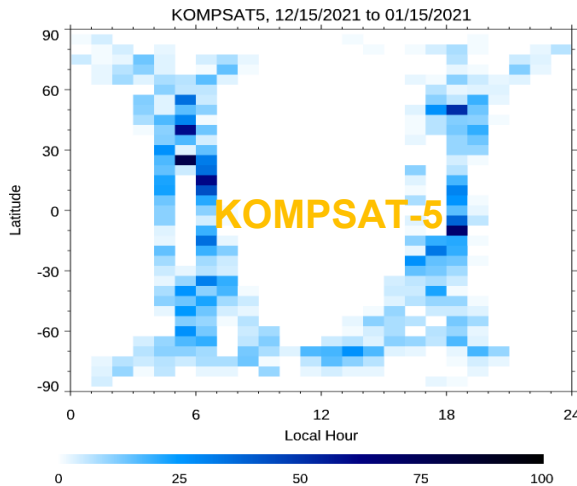
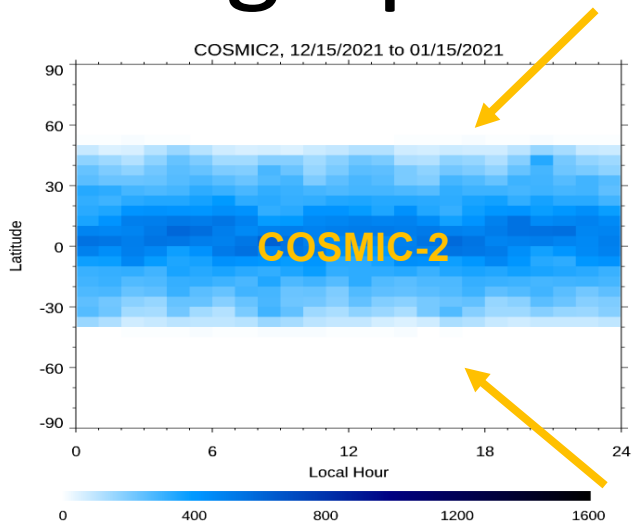


EUMETSAT (May 2022)

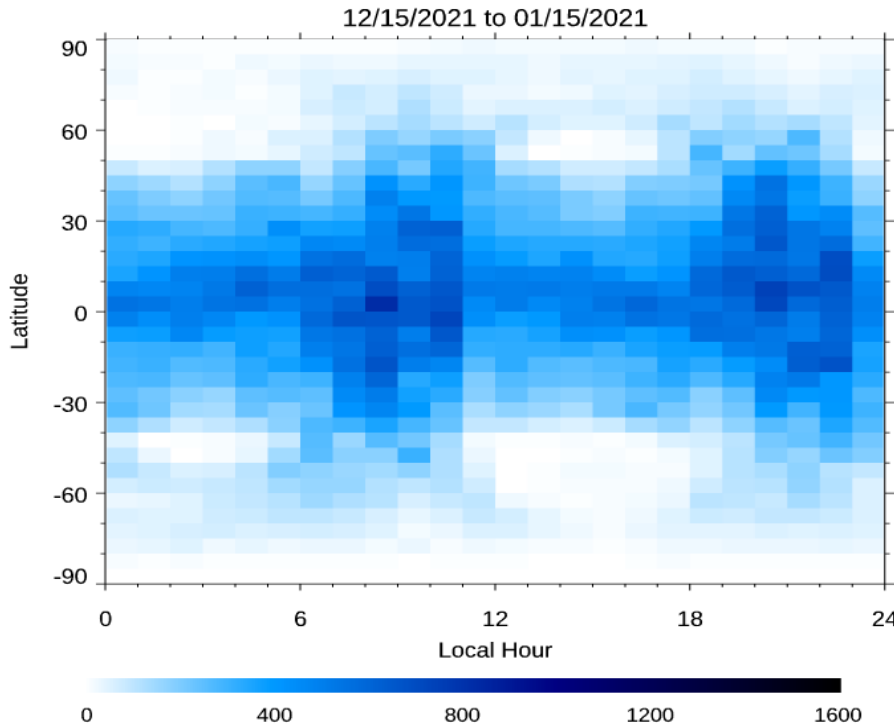
**And not only the numbers matter ...**

- Predicted numbers based on WMO/OSCAR
- Only operational missions with secured funding
- Nominal (baseline) mission performance
- GNSS constellations nominal

# Geographic and Local Time Coverage

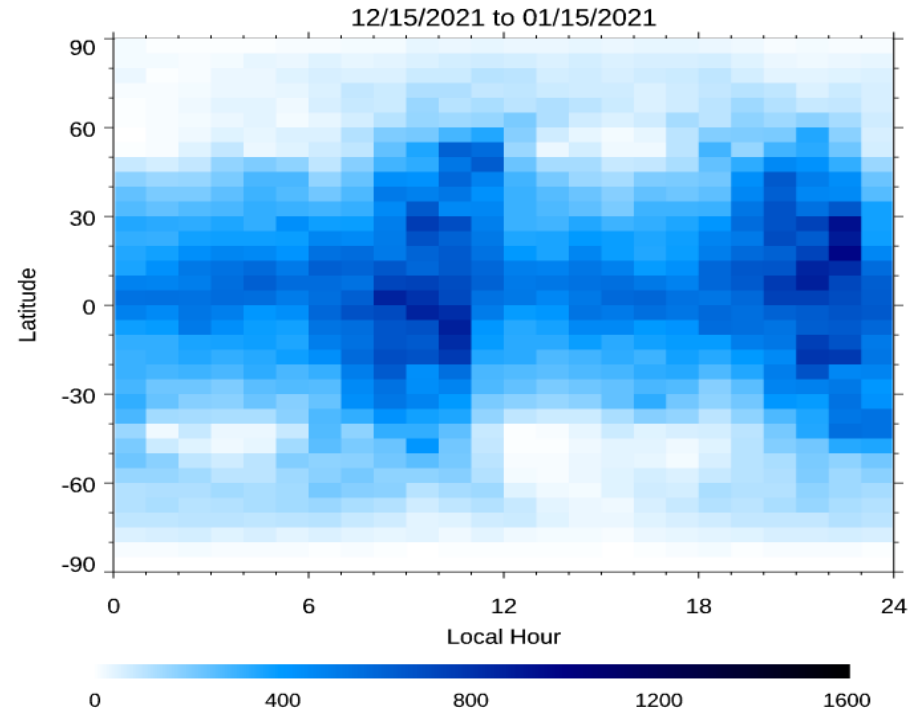


# Geographic and Local Time Coverage



COSMIC-2 + 3 Metops + Kompsat-5 + PAZ

Note that this is **not** a good sampling of the diurnal cycle ...



COSMIC-2 + 3 Metops + Kompsat-5 + PAZ  
+ SPIRE + GeoOptics

# Main Recommendations IROWG-8 (1)

- (1) IROWG reaffirms that all providers of RO observations should classify these as **essential** in the sense of **WMO Res 40**. IROWG stresses the importance of **free, timely and unrestricted access in real time to essential RO data**, and free and unrestricted access to **archived raw data** (including auxiliary data).
- (2) IROWG continues to recommend that **WMO** and **CGMS** should **coordinate any GNSS-RO data purchases**. Specifically, we suggest **convening a meeting of all agencies considering procuring these data**, in order to discuss if, how and when the current **20,000 daily target** will be met with **global and full local time coverage**.

# Main Recommendations IROWG-8 (2)

- (3) IROWG recommends that CGMS encourages technology and retrieval developments for improving **planetary boundary layer profiling** from GNSS-RO and their utilization in NWP data assimilation – and the further exploration of **RO-derived water vapor as a climate variable**.
  
- (4) Per CGMS priority HLPP 1.1.4 (optimized system for atmospheric and ionospheric RO observations), IROWG recommends that CGMS encourages on-going and future GNSS RO and non-RO missions, including potential commercial providers of RO observations, to **incorporate a complete set of ionospheric measurements**.



# Update on Recommendations (1)

- **Recommendation (2) (coordination of GNSS-RO data purchases)**  
IROWG acknowledges that such coordination has already started, however, further coordination would be beneficial to allow for optimal data use by the global community.
- Purchasers of RO data for NWP should document their access to raw data, so that such purchased data can be used reliably in **climate applications**, where **traceability** of the measurements to fundamental units (e.g. definition of the second) is essential. For climate, appropriate **documentation** and **meta-data** need to be available with the provision of raw data.

# Update on Recommendations (2)

- IROWG appreciates the HLPP goal to “*Advance the atmospheric Radio Occultation constellation, with the long-term goal of providing **20 000 occultations per day on a sustained basis***” – but shares the concern, expressed in the recent WGIII risk assessment, that there is “**Continuity risk for the number and geographic distribution of radio occultations; especially in the low- to mid- latitudes**”, since there is currently no plan for a successor of the COSMIC-2 mission.
- Recent world events and ongoing conflicts have increased the use of GNSS radio jammers in various theatres. The RO community has begun to document the resulting degradation on RO measurements from radio frequency interference. It will be to the benefit of CGMS to acquire information on these developments and monitor their impacts to the observing system.

# Action Item Summary

There is one open action (for data providers) related to IROWG.

- **A48.02:** Data providers to document data processing QC processes (including a month of QC statistics, e.g. rejection percentage at each QC step) and space sampling information and provide to IROWG.
  - IROWG notes that this is a CGMS **recommendation to data providers**.
  - IROWG suggested that the relevant agencies **send representatives to the next IROWG meeting** so that detailed information on quality control methods and statistics can be discussed, leading to their improved documentation.
  - Certain WG members (from EUMETSAT, Spire and NOAA-NESDIS) agreed to **provide information on QC numbers in the next IROWG meeting**.

This action was also discussed during the latest Intersessional meeting, and there was agreement that this action should be closed during CGMS-50 – WGII and a new action should be formulated.

Welcome to IROWG-9 !



**8 – 14 September 2022, Seggau Castle, Leibnitz near Graz, Austria**

Together with the 7th **International Workshop on Occultations for Probing Atmosphere and Climate (OPAC)**.

Celebrating **20 years of OPAC**.

<https://opacirowg2022.uni-graz.at/en/>

# Summary

**Recommendations from IROWG-8** – carried forward. They include:

- IROWG reaffirms that all providers of RO observations should classify these as **essential** in the sense of **WMO Res 40**. IROWG stresses the importance of **free, timely and unrestricted access in real time to essential RO data, and archived raw data**.
- IROWG continues to recommend that **WMO and CGMS should coordinate any GNSS-RO data purchases**. Specifically, we suggest **convening a meeting** of all agencies considering procuring these data
- IROWG recommends that CGMS encourages **technology and retrieval developments for improving planetary boundary layer profiling** from GNSS-RO and their utilization in NWP data assimilation – and the further exploration of RO-derived **water vapor as a climate variable**.
- Per CGMS priority HLPP 1.1.4 (optimized system for atmospheric and ionospheric RO observations), IROWG recommends that CGMS encourages on-going and future GNSS RO and non-RO missions, including potential commercial providers of RO observations, to incorporate a **complete set of ionospheric measurements**.
- **IROWG-9**: September 8-14, 2022, Seggau, Austria
- **Hui Shao** will be our next IROWG co-chair.

# Main Outcomes 1

IROWG Recommendations resulted in CGMS recommendations:

| CGMS-50 recommendations – WGII |          |            |   |                                  |
|--------------------------------|----------|------------|---|----------------------------------|
| Actionee                       | AGN item | Rec        | Description   | Colour coding                    |
| CGMS Members                   |          | WGIIA50.04 | (IROWG) All providers of RO observations are encouraged to classify RO data as <b>core data</b> in the sense of the WMO Unified Data Policy (Res. 1). Therefore, <b>free, timely and unrestricted access shall be provided to NRT RO data</b> and free and unrestricted access shall be provided to archived <b>raw data (including auxiliary data)</b> | <b>High</b><br>Level<br>Priority |
| WMO and CGMS Members           |          | WGIIA50.05 | (IROWG) WMO and CGMS are encouraged to <b>coordinate any GNSS-RO data purchases</b> to ensure the current <b>20,000 daily target</b> identified in HLPP is met with <b>global and full local time coverage</b>  | <b>High</b><br>Level<br>Priority |

# Main Outcomes 2

IROWG Recommendations resulted in CGMS recommendations:

| CGMS-50 recommendations – WGII |          |            |   |                                     |
|--------------------------------|----------|------------|---|-------------------------------------|
| Actionee                       | AGN item | Rec        | Description   | Colour coding                       |
| CGMS Members                   |          | WGIIA50.06 | (IROWG) CGMS are recommended to encourage technology and retrieval developments for <b>improving planetary boundary layer profiling</b> from GNSS-RO and their <b>utilization in NWP</b> data assimilation – and the further exploration of <b>RO-derived water vapor</b> as a climate variable   | Best Practices and Periodic actions |
| CGMS Members                   |          | WGIIA50.07 | (IROWG) <b>Purchasers of RO data</b> for NWP is encouraged to <b>document their access to raw data</b> , so that such purchased data can be used reliably in climate applications, where <b>traceability</b> of the measurements to fundamental units (e.g. definition of the second) is essential. For climate, appropriate <b>documentation and meta-data</b> need to be available with the provision of raw data | Best Practices and Periodic actions |



# More things to do

- Formulate **recommendations of the subgroups (Saturday morning)**
- **Next IROWG workshop – Q2 2024 ?, where?**
- Coordination with other planned workshops.

Thank you!